Mass Wasting

Chapter 7

Learning Objectives

- Understand slope processes and the different types of landsides
- Know the forces that act on slopes and how they affect the stability of a slope
- Know what geographic regions ore at risk from landslides
- Know the effects of landslides and their linkages with other natural hazards
- Understand how people can affect the landslide hazard
- Be familiar with adjustments we can make to avoid death and damage caused by landslides

Mass Wasting

- **Mass Wasting is the process whereby weathered material is moved a relatively short distance downslope under the direct influence of gravity.**
- **The controls or causes of mass wasting known as slope are:**
  - **Angle of Repose** – the angle which cohesive layers of soil lie at rest on a slope if undisturbed unless the slope has a certain steepness.
  - **Water** – a lubricating medium that can diminish the friction between particles allowing easier sliding.
  - **Clay** – readily absorbs water allowing a spontaneously change from relatively solid mass to a near-liquid condition as result of a sudden disturbance or shock

Types of Landslides

- **Fall** -- simplest and most obvious form of mass wasting: when loosened by weathering on a very steep slope a rock fragment may simply be dislodged and fall, roll or bounce to the bottom of that segment of slope
  - **Results of a Fall**
    - Talus or scree — debris of the fall
    - Talus cones -- mounds of debris at the bottom of a fall
- **Slide** – an instantaneous collapse of a slope (a type of slope failure) and does not necessarily involve the lubricating effects of water or clay.

Results topographically result of a **landslide**

- On the hill were the slide originated, there is a deep extensive scar
- In the valley bottom where the slide material comes to rest a massive pile of highly irregular debris
- On the up-valley side of the debris, a lake may form

- **Slump** – involves slope failure in which the rock or regolith moves downward and at the same time rotates outward along a curved slide plane that has its concave side facing upward.
- **Flow** a sector of a slope becomes unstable, normally owing to the addition of water, and flows gently downhill. Some cases the mass moves more rapidly than the base and the sides.
- **Earthflow** – a portion of a water-saturated slope moves a limited distance downhill, normally during or immediately after a heavy rain.
- **Mudflow** – originates in drainage basins in arid and semiarid country when a heavy rain following a long dry spell produces a cascading runoff too voluminous to be absorbed into the soil.
    - **Debris flow** -- debris carried by the mudflow, causing much damage
- **Avalanches**- either earth or snow
- **Creep** – consists of a very gradual downhill movement of soil and regolith of unobtrusive that it can normally be recognized only by indirect evidence.
    - Caused by the interaction of various factors most significant being alternation of freeze-thaw and wet-dry conditions.
    - Very slow process. Can leave hillside ridges – *terracettes*.

Landslides

- Downslope movements are classified according to four variables:
    - The mechanism of movement (slide, fall, flow, or complex movement)
    - Type of earth material (solid rock, soft consolidated sediment, or loose unconsolidated sediment)
    - Amount of water present
    - Rate of movement (movement is considered if it can be discerned with the naked eye, otherwise it is considered as “slow”)
- **Forces on slopes: Look for relationship between**
    - The **driving forces** that move the materials
    - **Resisting forces** that oppose such movement
    - Most common driving force is the downslope component of the **weight of the slope material**

        - This weight can be from vegetation, fill material, or buildings
    - Most common resisting force is the **shear strength** of the slope material,
        - Its resistance to **failure by sliding or flowing along potential slip planes**
        - Potential slip planes are **geological surfaces of weakness** in the slope material such as bedding planes in sedimentary rocks and fractures in all types of rock
- Slope stability is evaluated by computing a **safety factor** (SF)
    - Defined as the ratio of the resisting forces to the driving forces
        - If the safety factor is greater than 1, the resisting forces exceed the driving forces
        - If the safety factor is less than 1, the driving forces exceed the resisting forces and slope failure can be expected
- These driving and resisting forces can change as conditions change
- Interrelationships are controlled by these variables
    - Type of earth materials
    - Slope angle and topography
    - Climate
    - Vegetation
    - Water
    - Time

Driving and Resisting Forces

- **The Role of Earth Material Type**
    - The **material composing a slope can affect both the type and the frequency of downslope movement**
    - The material characteristics include:
        - **Mineral composition**
        - **Degree of cementation or consolidation**
        - The **presence of zones of weakness**
        - The **ability of the earth material to transmit water**
    - These **characteristics are connected with different kind of rock over which they lie**

Driving and Resisting Forces

- **The Role of Slope and Topography**
  - Two factors are important with slope and topography
    - **Steepness and amount of topographic relief**
      - Slope – the slant or incline of the land surface
      - Relief – refers to the height of the hill or mountain above the land below
    - **Debris flows** – are thick mixtures of mud, debris, and water
      - Range in consistency from thick mud soups to wet concrete and are capable of carrying house-size boulders
      - They can move slowly or rapidly depending on conditions
- **The Role of Climate**
  - **Climate is defined as typical weather in an area over a period of years or decades or centuries**
  - It is **more than just the average of temperature and precipitation**
    - **Includes kinds of precipitation and its seasonal patterns**
    - These **patterns effect other factors of these forces**
    - **Seasonal patterns effect the vegetation, soils, and bare rocks**
    - **Dry areas are much different than wet areas**
- **The Role of Vegetation**
  - **Complex role in the development of landslides and related phenomena**
  - The **nature of vegetation in an area is a function of climate, soil type, topography, and fire history, each of which influences what happens on slopes**
  - **Vegetation is significant factor in slope stability for three reasons:**
    - **Vegetation provides a protective cover that cushions the impact of falling rain.** This cushion allows the water to infiltrate the slope while retarding the surface erosion
    - **Plant roots add strength and cohesion to slope material materials.** They act like steel rebar reinforcements in concrete and increase the resistance of a slope to landsliding

- **Vegetation also adds weight to a slope**

- **The Role of Water**
  - Water is almost **always directly or indirectly involved with landslides**
  - When studying a **landslide, scientists first examine what water is both on and within the slope**
  - **Water affects slope stability in three basic ways**:
    - Many landslides, such as shallow soil slips and debris flows, develop during rainstorms when slopes become saturated
    - Other landslides, such as slumps, develop months or even years following the deep infiltration of water into a slope
    - Water erosion of the base or toe of a slope decreases its stability

- **The Role of Time**
  - The forces acting on slopes often change with time
    - Example: both driving and resisting forces may change seasonally with fluctuations in the moisture content of the slope or with changes in the position of the water table
  - Much of the chemical weathering of rocks, which reduces their strength
    - This happens soil water is often acidic because it produces weak carbonic acid
    - In wet years the chemical reaction is greater, there is more chances to for the slope to slump

- **Snow Avalanches**
  - A snow avalanche is a rapid downslope movement of snow and ice, sometimes with the addition of rock, soil, and vegetation
  - Thousands happen all over the world where there are slopes which accumulate snow during the winter
  - The steeper the slope, the more chance for an avalanche
  - Two kinds of avalanches
    - Loose-snow avalanches – start a point and widen as they progress down the slop
    - Slab Avalanches – start as a cohesive blocks of snow and ice the move downslope

        - Triggered by the overloading of a slope or the development of zones of weakness in the snowpack

Geographic Regions at Risk from Landslides

- Landslides occur everywhere there are significant slopes and mountains
- There are three factors which expect to increase worldwide landslide activity
    - **Urbanization and development will expand in landslide-prone areas**
    - **Tree cutting will continue in landslide-prone areas**
    - **Changing global climate patterns will result in regional increases in precipitation**

Effects of Landslides and Linkages with other Natural Hazards

- **Effects of Landslides**
    - Landslides and related phenomena have the capacity to cause substantial damage and loss of life
    - Direct effects of landslides on people and property include being hit with or buried in falling debris
    - Landslides may also damage homes, roads, and utilities that have been constructed on the top or side of a hill
    - Indirect effects include flooding upstream and transmission of disease
- **Linkages between Landslides and Other Hazards**
    - Landslides and other types of mass movement are linked to almost every other natural hazard
    - Earthquakes, volcanoes, storms, and fires all have the potential to cause landslides

Natural Service Functions of Landslides

- It is hard to imagine natural service functions coming from landslides
    - But there are a few, to an old-growth forest a slide can be beneficial by
        - Increasing both plan and animal diversity.
        - In aquatic environments, damned lakes create new habitat for fish and other organisms

- Human Interaction with Landslides
    - Landslides and other natural ground fractures would happen with or without human intervention
    - Human intervention has increase the change of a landslide such as:
    - Timber Harvesting and Landslides
    - Urbanization and Landslides
- Minimizing the Landslide Hazards

Minimizing the Landslide Hazards

- **Minimizing the Landslide Hazards**
    - Necessary to identify the areas where landslides can occur, design slopes, or engineering structures to prevent landslides
    - Warn people of impending slides, and control slides after they have started moving
- Identification of Potential Landslides by their features
    - Crescent-shaped cracks or terraces on a hillside
    - A tongue-shaped area of bare soil or rock on a hillside
    - Large boulders or talus piles at the base of a cliff
    - A linear path of cleared or distributed vegetation extending down a hillslope
    - Tongue-shaped masses of sediment, especially gravel, at the base of a slope or at the base of a slope or a the mouth of a valley
    - An irregular, often referred to as hummocky, land surface at the base of a slope
    - **Prevention of large, natural landslides is difficult, but common sense and good engineering practices can help minimize the hazard**
    - **Prevention of Landslides**
        - **Drainage Control**
            - Surface and subsurface drainage control is usually effective in stabilizing a slope
            - Divert the water away from the slope by a series of drains
        - **Grading**
            - Although grading in some instances increases the chance of landslide,

planned grading can increase the stability

- **Slope Supports**
  - Most common methods of stabilization is building a retaining wall

- Landslide Warning System
  - Do not prevent landslides but they can provide time to evacuate people and their possessions
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  - Time to stop trains or reroute traffic
  - Surveillance of hazardous areas can be inspected for apparent changes
  - Other methods include electrical systems, tiltmeters, and geophones that pick up vibrations of moving soils